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E05B 49/02

(52) UK CL (Edition K)
E2A ALV

(56) Documents cited
GB 2055951 A GB 1294991 A WO 89/04904 A
US 4706084 A US 4393672 A

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UK CL (Edition K) E2A AEE ALV
INT CL^5 E05B

(54) Electronic lock and key systems

(57) The present invention proposes an electronic lock/key system having a key (11) wherein the actuating elements (that are read to enable the lock) are constituted by a multiplicity of analogue electrical resistances (15) representing a number unique to that key (within a set of such keys), the lock incorporating a reader and associated comparator that decides whether the key matches that lock (and only then allows the lock to be enabled).

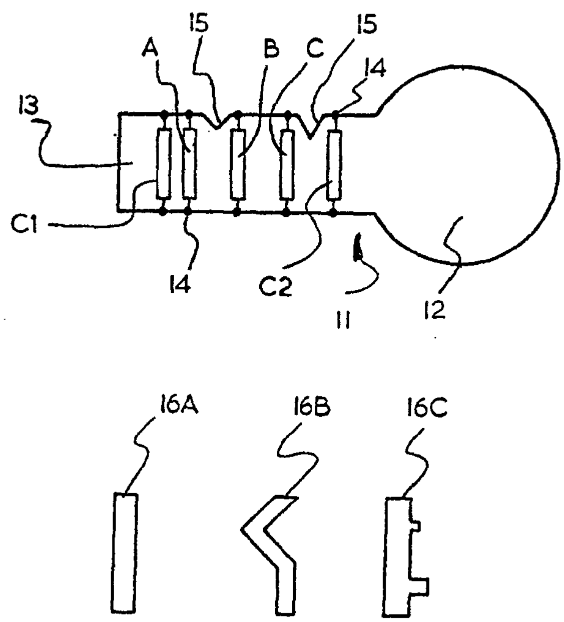

FIG 1

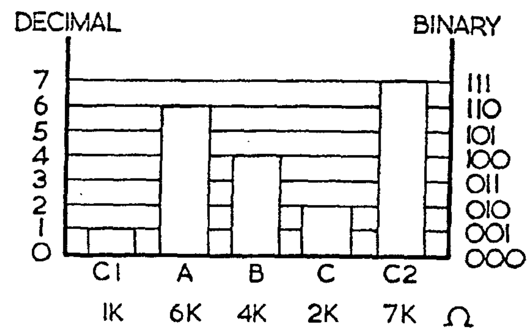

FIG 2

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

The claims were filed later than the filing date within the period prescribed by Rule 25(1) of the Patents Rules 1990.

This print takes account of replacement documents submitted after the date of filing to enable the application to comply with the formal requirements of the Patents Rules 1990.

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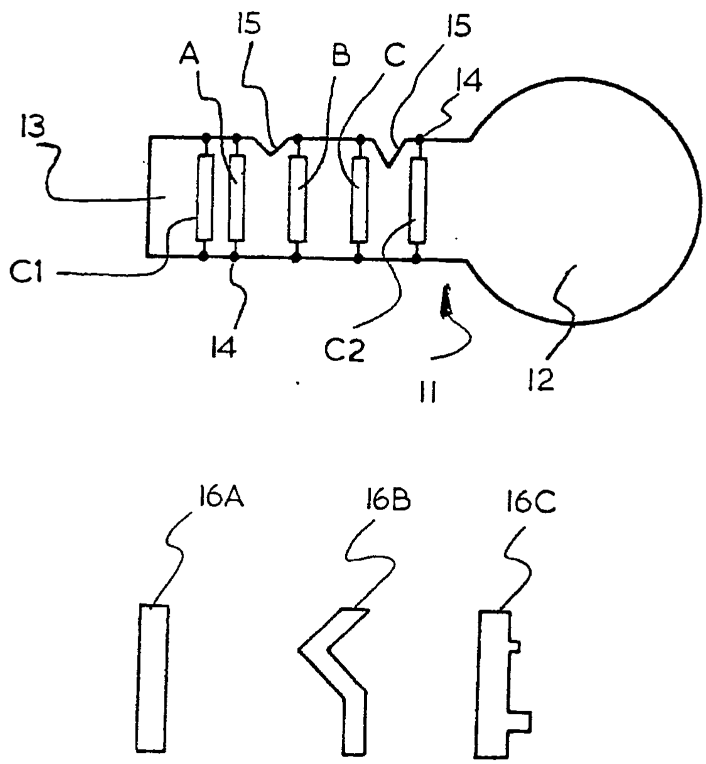
15
A
B
C
15
14
13
C1
14
C2
11
12
16A
16B
16C

FIG 1

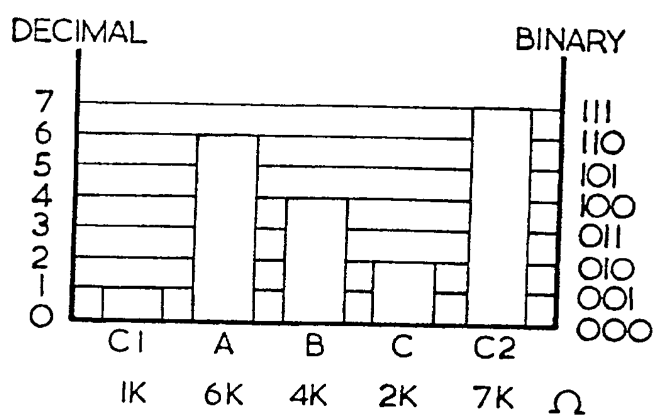
DECIMAL
BINARY
7
6
5
4
3
2
1
0
111
110
101
100
011
010
001
000
C1
A
B
C
C2
1K
6K
4K
2K
7K
Ω

FIG 2

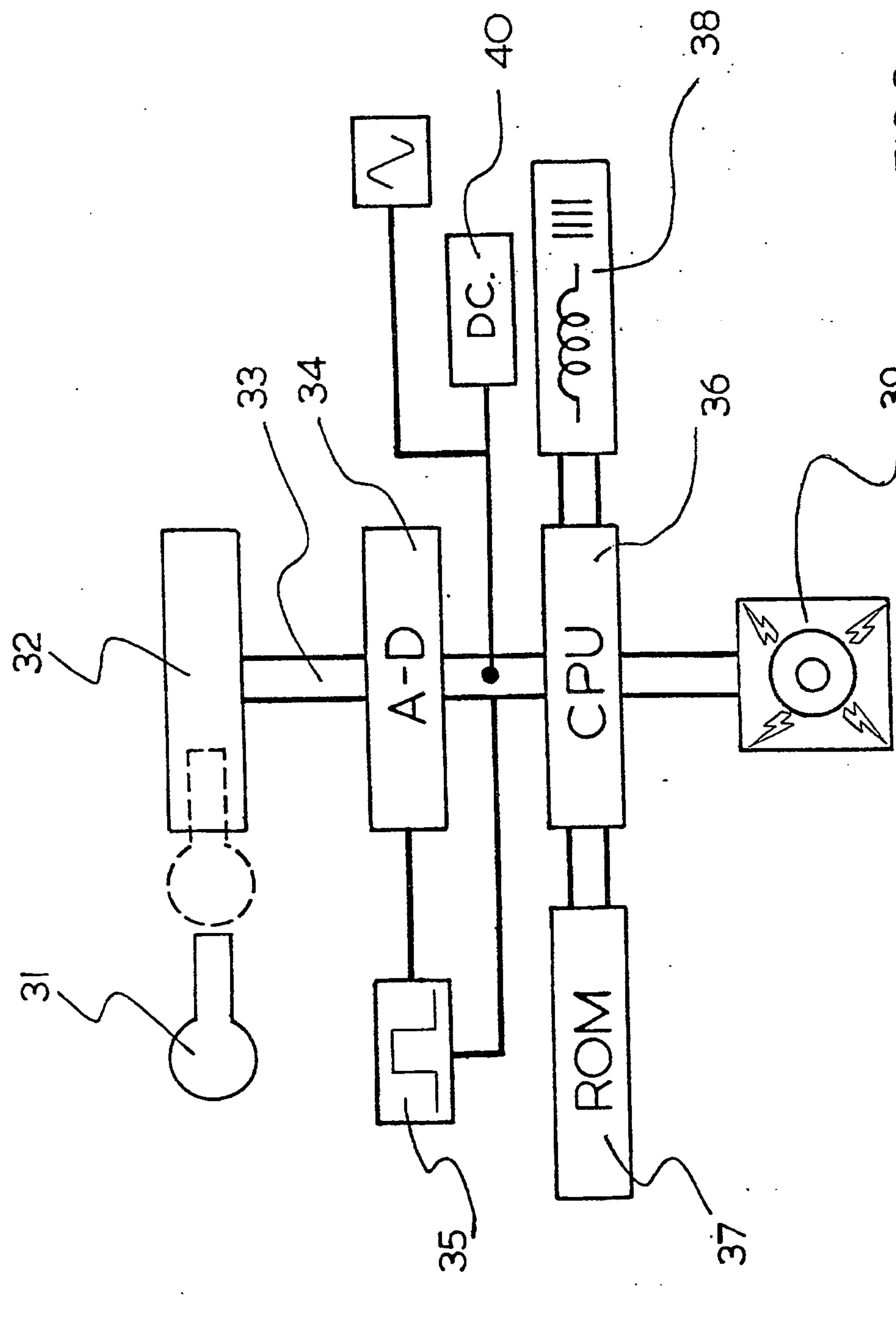

FIG 3

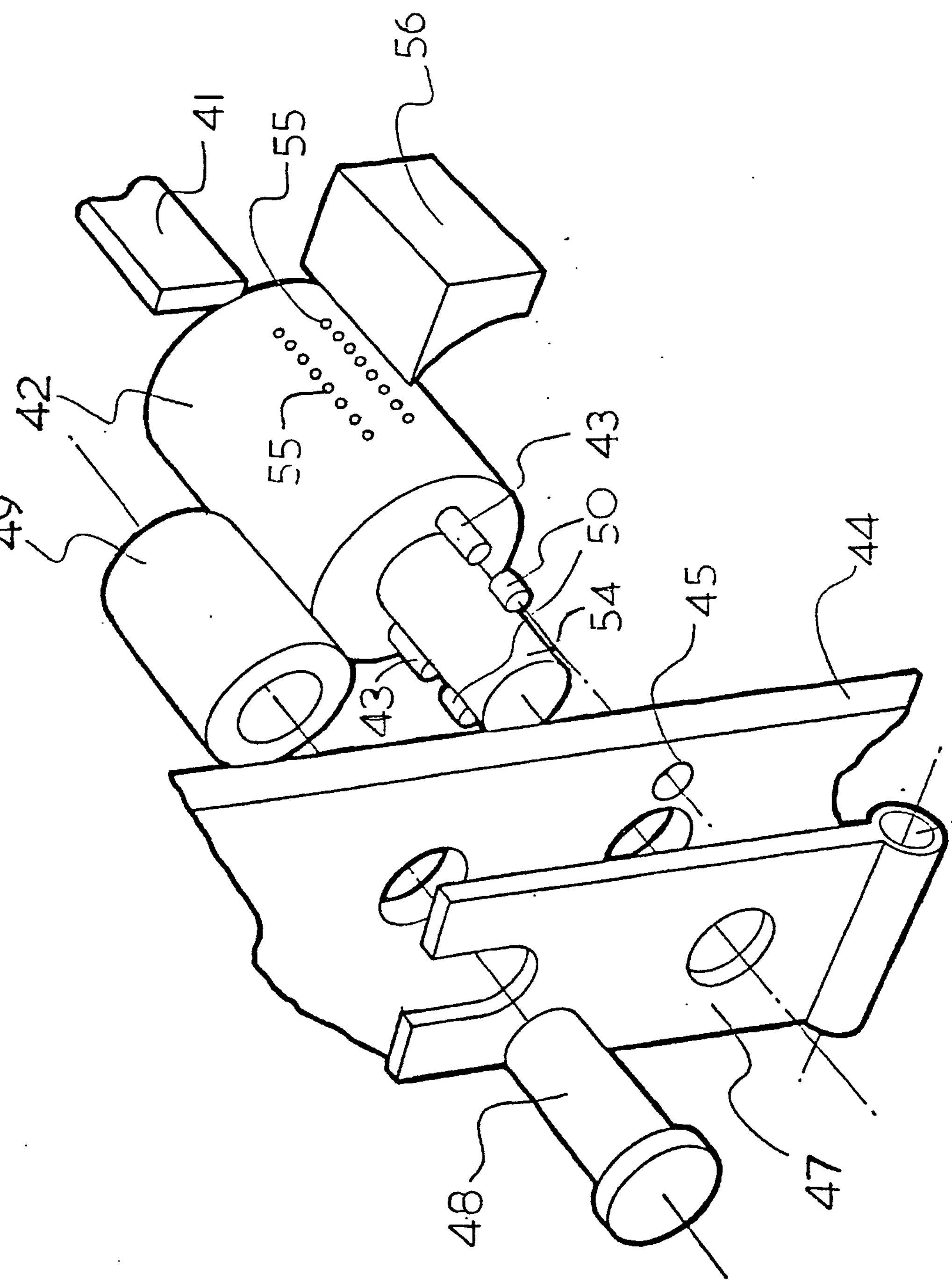

FIG 4

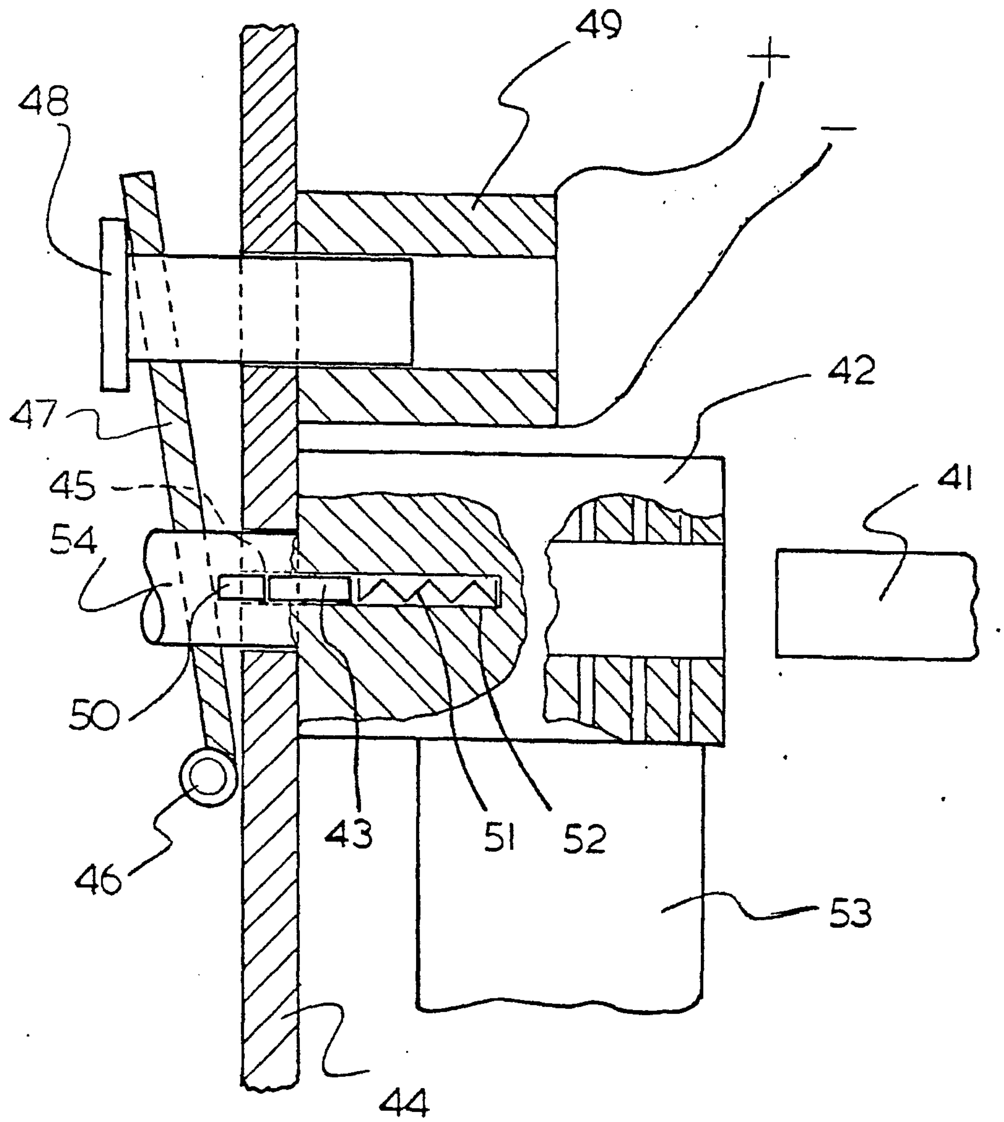

FIG 5A

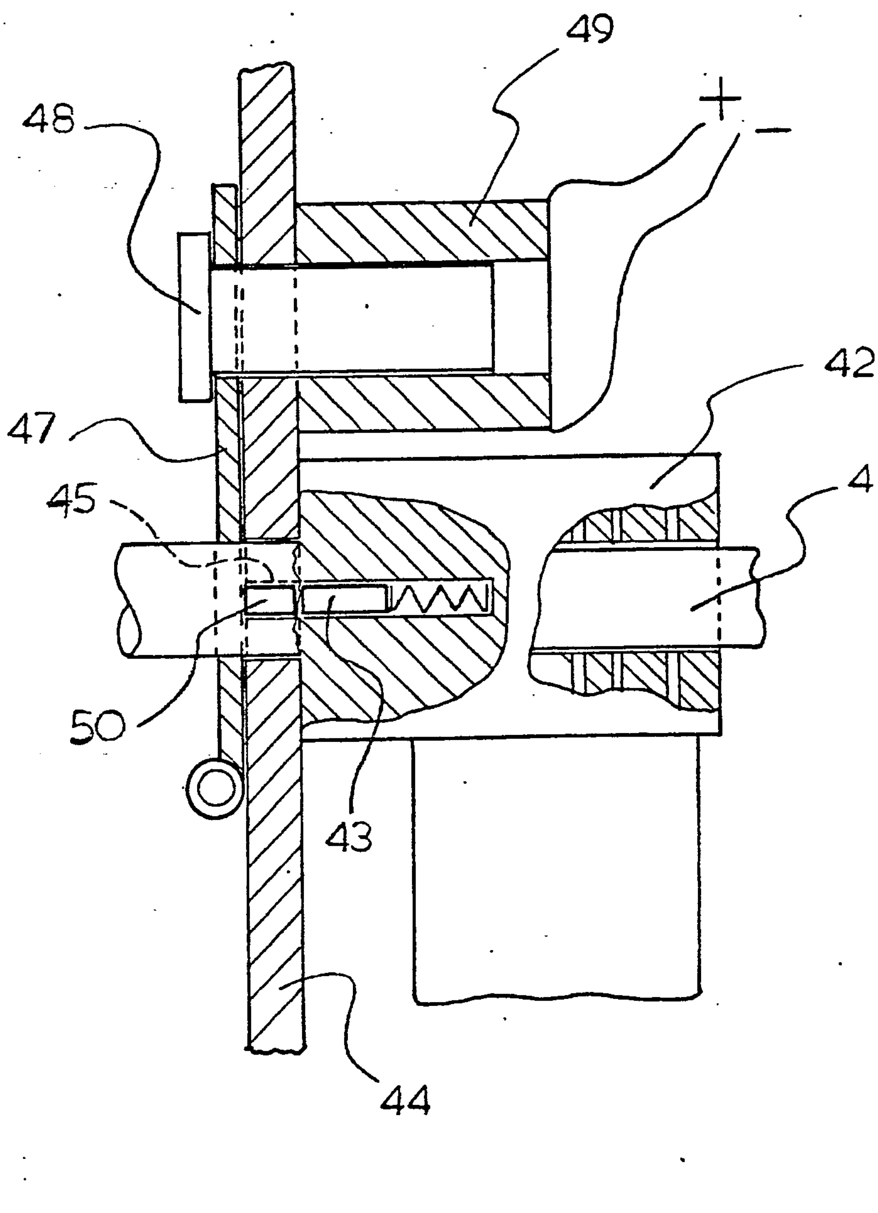

FIG 5B

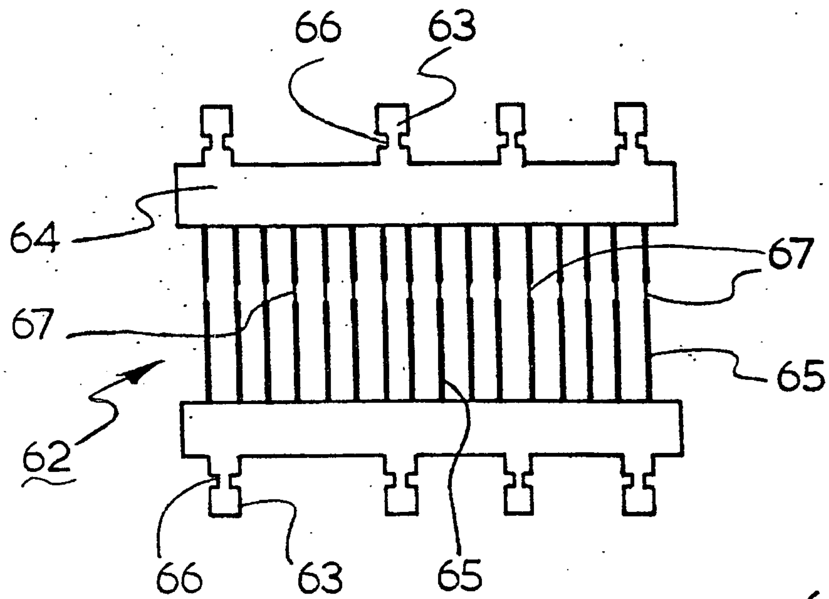

FIG 6A

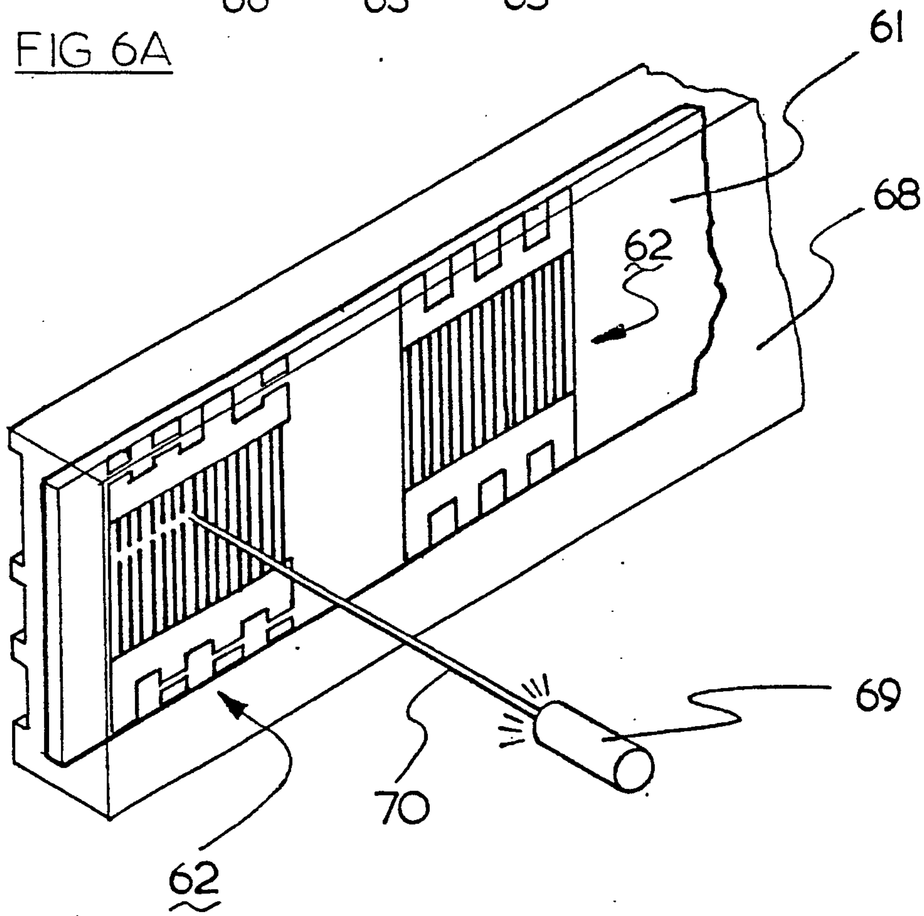

FIG 6B

Lock and Key Systems

This invention relates to lock and key systems, and concerns in particular novel, electronic varieties both of lock and of key.

Mechanical locks are basically of two types. The older is the lever (or rim, or mortise) lock, the younger the cylinder (or plug) lock (the latter is typified by that particular variety known as a Yale lock). Over the years each kind has become more and more complex, to provide both greater numbers (of different lock/key pairs) and greater security, but whereas even more numbers and more security is demanded the scope for further development is now extremely limited.

Basically, therefore, a quite different type of lock/key system has been developed - the "electronic" lock, wherein the key is a (passively or actively) magnetically or electronically, digitally encoded plastic card or strip, generally similar in principle to a credit card or a so-called smart card, and the lock is an electronically/mechanically activated device that is enabled by insertion thereinto (via) an associated "reader" of some sort) of the appropriate card-like key. These electronic locks have been quite successful, especially in areas where security is all important, but nevertheless do suffer from a number of disadvantages. Thus, they tend to be rather expensive, and surprisingly unreliable. In addition, both the locks and their keys can be somewhat bulky. Moreover, it has not proven easy

to "bypass" the locks in an emergency (such as a fire, for instance).

The present invention proposes a rather different variety of electronic lock/key system. More specifically, it suggests a key wherein the actuating elements (that are read to enable the lock) are constituted by a multiplicity of analogue electrical resistances representing a number unique to that key (within a set of such keys), the lock incorporating a reader and associated comparator that decides whether the key matches that lock (and only then allows the lock to be enabled). In addition, the invention suggests a form of electromechanically operated lock (preferably for use with a key of the invention) wherein the physical enabling of the lock - the permitting of the lock's deadbolt to be driven to or fro - is effected by a solenoid-operated lever suitably displacing a detent associated with the deadbolt.

In one aspect, therefore, the invention provides an electronic key for use with an electronic lock-and-key system, which key comprises:

a lock-insertable body supporting a multiplicity of electrical resistors the value of each of which is readable by the lock when the key is inserted thereinto, which values can be used to compute a number which is unique to, and which determines whether or not the lock is enabled by, that key.

In another aspect the invention provides an electronic lock for use with an electronic lock-and-key system comprising an electronic key as just defined hereinbefore and a lock into which that key can be inserted and which has a unique enabling code number

stored therein, which lock contains:

key resistor reading means whereby the values of the key's resistors may be determined;

comparator means, by which there may be computed from the read key resistor values a number specific to the key, and by which the computed key number may be compared with the lock code number; and

lock enabling means operable by a signal from the comparator means if and when the computed key number and the lock code number are the same.

In yet another aspect, the invention provides an electromechanical lock for use as the electronic lock (of the electronic lock-and-key system) as just defined hereinbefore, which lock comprises, as its lock enabling means:

first body section means, in which are bias mounted to project thereout of a number of detent pin tumblers;

second body section means mounted adjacent the first body section means and apertured to allow the pin tumblers to project thereinto (to prevent lateral relative movement of the two sections, which relative movement would open or disengage the lock); and

solenoid-operated pin tumbler displacement means, whereby upon operation of the associated solenoid all the pin tumblers projecting into the apertured section means are displaced therefrom, thus enabling lateral relative movement of the two sections and therefore allowing the lock to be opened (disengaged).

The invention provides an electronic key for an electronic lock-and-key system, an electronic lock for the lock-and-key system, and - as a particular embodiment of the electronic lock - an

electromechanically-enabled lock. Each of these is now described in turn in more detail, but as a general comment it may first be said that, while there can be envisaged non-insertable, non-turnable key/lock systems - for instance, one where the key is placed against a pad surface and simply pressed (to push the pad and operate the lock) - the invention is concerned primarily with systems wherein either the key itself or a handle is turned (or slid sideways) to operate the lock, or where a secondary electromagnetic unlocking mechanism is activated. Thus, the key/lock system may, like a Yale system, be one where the key is inserted and turned to open the lock. Alternatively, it may be one where the lock is operated by turning or sliding a separate handle or knob, and the key upon insertion is not turned or slid itself but rather enables this turning or sliding of the handle or knob. Alternatively again, the system may incorporate a further electromagnetic mechanism that disengages the lock simply when the correct key is inserted.

The electronic key of the invention has a body carrying resistors defining that particular key. The body may be of any overall shape or size, as desired, and may have any cross-section (in this way it may act as a mechanical key as well as an electronic one). One preferred shape is that of an elongate flat plate.

The key body - and, indeed, the whole of the key - is conveniently of a suitable electrically non-conductive plastics substance (Nylon, for example). For production purposes this material can with advantage be transparent to infra-red light (so enabling an IR-laser to beam through the material to the resistors therewithin) but opaque to visible light (so preventing

the nature of the internal resistors being apparent to the naked eye).

The body supports a multiplicity of resistors, and these may be either surface mounted or, and preferably, encapsulated within the key body, with only their terminal ends projecting therefrom (so as they can make contact with the appropriate elements within the key reader, and thus enable the value of each resistor to be determined by direct measurement).

There is a multiplicity of resistors, each representing a digit in a code number, and clearly there may be as many resistors as needed to achieve the desired size of code number (the bigger the number, the more key combinations are possible). At present it is felt that eight resistors, giving an eight-digit code number, is satisfactory, but fewer - down to three, say - or more - up to 16, say - would be possible.

Each resistor has a value (both absolute, and relative to the others) that determines the digit it represents. On a relative basis, and using, for convenience, the decimal system, each resistor could have a value within a range of values representing the digits 0, 1, 2 ... 7, 8 and 9. In such a system having eight resistors there could thus be one hundred million different keys (from 00,000,000 to 99,999,999). However, for control purposes - to allow the system to check that it is performing properly, and to enable it to work even if the reader, say, is inaccurate - it may be desirable to designate one or two resistor positions as "control" positions, providing a reference point against which the others are assessed and "normalized". Thus, for example, one pre-chosen resistor position (the one at one end) might be designated a particular low value (0, say) and a second (the one next door, or the

one at the other end) a particular high value (9, say), and all the rest might then be assessed relative thereto. So, in an eight resistor system with two control positions only six resistors actually define the key number.

Of course, by varying the position of the control resistor(s), so there can be provided series or sets of keys; the key in one series could have the same resistors as a key in another, but the two would not open the same doors because their digit values, worked out on the basis of (probably) different control position resistor values, would (probably) be different.

As to the resistors' absolute values, these could be anything suitable - from ones or tens of ohms, say, to ones or tens of thousands of ohms. Naturally, the actual absolute values would match the reader's capabilities (and those of the comparison and calculating equipment).

The resistors can be formed on or in the key in any appropriate way, though most conveniently they will be thin film resistors sandwiched between two sealed layers of key body material. However, one advantageous physical form and shape for each resistor is that of a multiplicity of individual resistor elements disposed in parallel between two bus bars each of which is in turn connected to several terminal pads spaced therealong. The actual value of each "multi-element" resistor unit can be chosen and set by cutting, conveniently with a laser, one or more of the individual resistor elements (the more that are cut the higher the resulting resistance of the unit), while the choice of a particular terminal (by similarly cutting the tracks from the relevant bus bar to all its other terminals) allows the key to be used only with a reader having

correspondingly off-set read means. This idea is discussed further hereinafter with reference to the accompanying Drawings.

The second aspect of the invention is an electronic lock to be used with the invention's key; when the key is inserted into the lock its resistor values are read and used to compute a number "unique" to that key, which number determines whether or not the key is enabled.

The key resistor reading means may take any appropriate form, but in the case of a key the resistors of which are buried except for end contacts the reader will have matching contacts enabling each resistor to complete a circuit that outputs a value (a voltage drop, say) representative of the resistor value.

The lock also includes comparator means that uses the resistor-representing value to compute the key number and then compares this with the lock number. This compute/compare is best done on a binary digital basis, using a small microprocessor. Accordingly, the resistor-representing values are first digitized (before or after normalization against any reference values) by a suitable A-D (Analogue-to-Digital) converter, and then compared with the lock's (stored) code number. And if they match, the comparator means outputs a signal to enable the lock - to allow it to be unlocked. Of course, if the computed key number does not match the lock number then it can be arranged that the comparator triggers or alerts some sort of alarm or security system.

The lock thus includes enabling means operable (on receiving a suitable signal from the comparator means)

to permit the lock to be unlocked (whether by turning or sliding the key or some separate handle, or even by some secondary electromagnetic unlocking mechanism). This enabling means may take any suitable form, but one particularly preferred form involves biased pin tumblers, much as in a Yale lock, that normally (when the lock is locked) project across the boundary between two relatively movable parts of the mechanism (first and second body section means), to prevent such movement, which pin tumblers can all simultaneously be displaced into non-projecting (unlocked) positions by a solenoid-operated mechanism actuated by a signal from the comparator means.

The lock of the invention has a first body section containing a number of pins bias-mounted therein to project out thereof. The pins are to prevent lateral movement - either translational or rotational - of the first section relative to the second body section. There may only be a single pin, but preferably - and to give the lock greater mechanical strength to resist a brute-force attempt to open it - there are at least two.

The second body section is in effect merely a piece placed adjacent the first and having apertures therein into which usually project the pins in the first section. It is convenient if this second section be a plate (or plate-like body) against which the first section abuts, the pin apertures therein extending right through the plate.

The lock also includes solenoid-operated pin tumbler displacement means - that is, means which, when actuated by a solenoid driving mechanism, displace the pins out of the second section (and thence flush with the surface of the first section) to allow first and second section relative lateral movement. One preferred

form of this displacement means, especially suited for use with the plate-like second section mentioned above, comprises an appropriate number of driver pins disposed within each plate pin tumbler aperture so as to be in contact with each pin tumbler at one end (but projecting out of the plate at the other end, these driver pins being associated with a plate-hinged lever operable under the influence of a solenoid to press flat against the plate across the driver pins and so push them - and thus the pin tumblers - through the plate until the pin tumblers clear the plate (and are more or less flush with the first section surface). Although the lever could itself be the "core" of the solenoid, most preferably the solenoid has a separate core mechanically linked to the lever.

The invention's preferred lock uses a solenoid-operated mechanism to displace the pin tumblers. The solenoid naturally requires an electrical power source, and this can conveniently be the mains, suitably supplied to the lock (though a battery system with a battery in the lock - or, even, in the key - is possible).

An embodiment of the invention is now described, though by way of illustration only, with reference to the accompanying Drawings in which:

Figure 1	shows a side view of a key of the invention, with three possible sectional views;
Figure 2	represents the resistance values of the key of Figure 1, and their conversion to a number in digital form;
Figure 3	shows a block diagram relating to the electronics, etc., required for the use of a key-and-lock system of the invention;
Figure 4	shows (in exploded perspective) the mechanical arrangement of a key-and-lock system of the invention;
Figures 5A & B	show in see-through form the electromechanical nature of a preferred lock of the invention; and
Figures 6A & B	show in elevation and see-through perspective form a particular embodiment of key resistor unit.

Figure 1 shows a key-shaped key (generally 11) having a handle (12) and key bit (13). The key bit contains embedded therein five resistors (C_1, A, B, C and C_2; see also Figure 2). These are here shown, but normally would be invisible save for the contacts (as 14) at their ends. They have absolute values of 1, 6, 4, 2 and 7 Kilohms respectively, and the ones at either end (C_1 and C_2) are used as control values by the reader (not shown).

The key has two notches (as 15) on the top edge, and may have a section like one of the three (16<u>A</u>, <u>B</u>, and <u>C</u>) shown below. It may thus be a conventional mechanical key as well as an inventive electronic one.

Conversion of the key resistor analogue values into digital values is shown diagrammatically in Figure 2. There are eight levels of digitization (0, 1.... 6, 7) so that, using resistors C_1 and C_2 as relative control values - giving resistors A, B and C pure number values of 6, 4 and 2 - the key has a binary digital code of [001] 110 100 101 [111]. If all the five-resistor keys in this series use the end values as the controls, and require them to represent 1 and 7 [001 and 111]. then from the three centre resistors (A, B and C), each of which can have eight values (0 to 7), it will be seen that the series can have $8\times8\times8=8^3 = 512$ different keys.

Figures 6A & B show in more detail how the individual resistors C_1, A, B etc can be made.

In this embodiment of the key there is a plate (61) onto which is printed a number of resistor sites (as 62). One of these sites is shown in detail in Figure 6A. The site consists of eight input/output

contacts (as 63) that are joined four each to two input/output bus bars (as 64) with a rank of sixteen resistor elements (as 65) joined in parallel therebetween. Each contact 63 and resistor element 65 on the plate 61 has a restricted section (as 66, 67), in line one with the next. A typical key will carry up to eight such sites, two of which operate as the key code control values.

The plate 61 is embedded into a plastics casing (68) opaque to visible light but transparent to infra-red. This package forms the blank key.

Setting the various resistor values on the key is achieved by the use of a laser (69), as shown in Figure 6B. Under computer control, the laser beam (70) scans the lines of restrictions 66, 67, and is pulsed to burn selectively the chosen conducting layers at these points. Where the laser burns the layer it no longer conducts. On the input/output contacts 63 only one restriction is left intact on each side, giving a positional permutation of sixteen if four contacts are originally present on each.

Each resistor element conveniently has the same value, typically 1 Megohm. The resistance of the full set of sixteen in parallel is then 6.25 Kilohm; as each is cut so the resistance increases up to a value of 1 Megohm (or, of course, infinity if all are cut). The sixteen steps, combined with the sixteen permutations of input/output contacts, give each site a range of 256 possibilities. On an eight-site key, where two of the sites are control values, there are thus 2.81×10^{12} variants. Further possibilities can be obtained by changing the location of the control sites.

The plastics casing may also be moulded to any appropriate shape, in order to provide a physical (as

well as an electronic) barrier for different suites of key. Moreover, yet higher security can be provided by the key containing a double sided plate 61, increasing the number of sites to sixteen (and therefore offering a number of variants approaching 5.19×10^{33} with two control sites).

The operation of the system of the invention is shown (in part) in the block diagram of Figure 3. A key (31) comprising the requisite number of resistances in a structure suitable to the purpose is inserted into a reader (32). From the reader runs a data path (33) to an analogue-to-digital converter (34), which includes a reference voltage segment (35). The output signal from the A-D converter 34 is passed as a series of digital values to the central processor unit (CPU 36). Here the series of values from the A-D converter 34 is compared with the series stored in a section of Read Only Memory (ROM 37). If the numbers are congruent the CPU 36 signals an actuating circuit (38) either directly or indirectly to operate. If the numbers are incongruent the CPU either ignores the attempt or sets an alarm circuit (39) into operation.

In the event of failure of a transformed mains supply, the processor will be maintained by a battery back-up (40) which will be recharged once normal power has been restored.

Figure 4 shows the general mechanical arrangement of a lock-and-key system of the invention, while Figures 5A and 5B show how it operates the lock.

A key (41) is inserted into a barrel-shaped lock body first section (42). Extending from this first

section's rear face are two pin tumblers (as 43) bias-mounted (by springs 51) in passageway (52) - shown in Figures 5A and 5B). Adjacent the rear face is a plate-like second section (44) having apertures (as 45) therein corresponding to the pin tumblers 43.

These pin tumblers are spring-biased to project out of the barrel 42 and into the apertures 45, thus preventing lateral movement of the barrel 42 relative to the plate 44.

Hingedly mounted (at 46) to the rear of the plate 44 is a lever arm (47) operated by a mechanical linkage (48) to a solenoid (49) mounted on the front of the plate 44 adjacent the barrel 42. Finally, disposed in the apertures 45 in the plate 44, and extending between each pin tumbler 43 and the lever arm 47, are driver pins (as 50) of a length matching the thickness of the plate; as the lever arm 47 is pivoted towards the plate 44 so it pushes all the driver pins 50 fully into the apertures 45, and the driver pins in turn push the spring-biased pin tumblers 43 clear of the plate 44 (this is shown in Figure 5B), so allowing relative lateral movement between the barrel 42 and the plate 44. This movement is transfeered _via_ the output shaft (54) to the lock latch mechanism (not shown), and thus the lock may be unlocked.

Whether or not any particular key 41 operates the lock depends upon the key and lock matching physically, and upon the key and lock numbers being congruent. In the embodiment of Figures 4 and 5 the key resistors terminate in contacts (not shown) to corresponding external terminals (as 55) in the surface of the body section 42, and these are "read" by the appropriate contacts (not shown) in the reader means (56).

CLAIMS

1. An electronic key for use with an electronic lock-and-key system, which key comprises:

a lock-insertable body supporting a multiplicity of electrical resistors the value of each of which is readable by the lock when the key is inserted thereinto, which values can be used to compute a number which is unique to, and which determines whether or not the lock is enabled by, that key.

2. An electronic key as claimed in Claim 1, wherein the body carrying the resistors has the shape of an elongate flat plate.

3. An electronic key as claimed in either of the preceding Claims, wherein the key body is made of a suitable electrically non-conductive plastics substance which is transparent to infra-red light but opaque to visible light.

4. An electronic key as claimed in any of the preceding Claims, wherein the resistors are encapsulated within the key body, with only their terminal ends projecting therefrom.

5. An electronic key as claimed in any of the preceding Claims, wherein there are eight resistors.

6. An electronic key as claimed in any of the preceding Claims, wherein one or two resistor positions are used as "control" positions, providing a reference point against which the others are assessed and "normalized".

7. An electronic key as claimed in any of the preceding Claims, wherein the resistors are thin film resistors sandwiched between two sealed layers of key body material.

8. An electronic key as claimed in any of the preceding Claims, wherein each resistor is a multiplicity of individual resistor elements disposed in parallel between two bus bars each of which is in turn connected to several terminal pads spaced therealong, such that the actual value of each "multi-element" resistor unit can be chosen and set by cutting one or more of the individual resistor elements, while the choice of a particular terminal (by similarly cutting the tracks from the relevant bus bar to all its other terminals) allows the key to be used only with a reader having correspondingly off-set read means.

9. An electronic key as claimed in any of the preceding Claims and substantially as described hereinbefore.

10. An electronic lock for use with an electronic lock-and-key system comprising an electronic key as defined in any of the preceding Claims and a lock into which that key can be inserted and which has a unique enabling code number stored therein, which lock contains:

key resistor reading means whereby the values of the key's resistors may be determined;

comparator means, by which there may be computed from the read key resistor values a number specific to the key, and by which the computed key number may be compared with the lock code number; and

lock enabling means operable by a signal from the comparator means if and when the computed key number and the lock code number are the same.

11. An electronic lock as claimed in Claim 10, wherein, for use with a key the resistors of which are buried except for end contacts, the reader has matching contacts enabling each resistor to complete a circuit

that outputs a value representative of the resistor value.

12. An electronic lock as claimed in either of Claims 10 and 11, wherein the comparator means effects a compute/compare on a binary digital basis, using a microprocessor, and the resistor-representing values are first digitized by a suitable A-D converter, and then compared with the lock's (stored) code number, and if they match, the comparator means outputs a signal to enable the lock.

13. An electronic lock as claimed in any of Claims 10 to 12 and substantially as described hereinbefore.

14. An electromechanical lock for use as the electronic lock (of the electronic lock-and-key system) as defined in any of Claims 10 to 13, which lock comprises, as its lock enabling means:

first body section means, in which are bias mounted to project therefrom a number of detent pin tumblers;

second body section means mounted adjacent the first body section means and apertured to allow the pin tumblers to project thereinto (to prevent lateral relative movement of the two sections, which relative movement would open or disengage the lock); and

solenoid-operated pin tumbler displacement means, whereby upon operation of the associated solenoid all the pin tumblers projecting into the apertured section means are displaced therefrom, thus enabling lateral relative movement of the two sections and therefore allowing the lock to be opened (disengaged).

15. An electromechanical lock as claimed in Claim 14, wherein the first body section contains at least two pins bias-mounted therein to project out thereof.

16. An electromechanical lock as claimed in either of Claims 14 and 15, wherein the second body section is a body placed adjacent the first and having apertures therein into which usually project the pins in the first section, this body being a plate against which the first section abuts, the pin apertures therein extending right through the plate.

17. An electromechanical lock as claimed in any of Claims 14 to 16, wherein the solenoid-operated pin tumbler displacement means comprises an appropriate number of driver pins disposed within each plate pin tumbler aperture so as to be in contact with each pin tumbler at one end (but projecting out of the plate at the other end), these driver pins being associated with a plate-hinged lever operable under the influence of a solenoid to press flat against the plate across the driver pins and so push them - and thus the pin tumblers - through the plate until the pin tumblers clear the plate (and are flush with the first section surface).

18. An electromechanical lock as claimed in any of Claims 14 to 17 and substantially as hereinbefore described.

Patents Act 1977
Examiner's report to the Comptroller under (:ction 17 (The Search Report)

Application number

9025588.6

Relevant Technical fields

(i) UK Cl (Edition K) E2A(ALV,AEE)

(ii) Int Cl (Edition 5) E05B

Databases (see over)

(i) UK Patent Office

(ii)

Search Examiner

P J SILVIE

Date of Search

13 JANUARY 1992

Documents considered relevant following a search in respect of claims 1,10

Category (see over)	Identity of document and relevant passages	Relevant to claim(s)
X	GB 2055951 A (DAY) see page 4, lines 92-96	1,10
X	GB 1294991 A (BOSTROM)	1
X	WO 89/04904 A (NCR)	1,10
X	US 4706084 A (MEYERS)	1
X	US 4393672 (GELHARD)	1,10

Category	Identity of document and relevant passages	Relevant to claim(s)

Categories of documents

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